Predictive Analytics on Accident Data Using Rule Based and Discriminative Classifiers

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Abstract

Abstracting useful information from a big data has always been a challenging task. Data mining is a powerful technology with great potential to extract knowledge based information from such data. Prediction can be done with past and related records in different fields. Risk and safety have always been an important consideration in the field of aircraft. Prediction of accident in aircraft will save life and cost. This paper proposes an accident prediction system with huge collection of past records by applying effective predictive data mining techniques like Decision Tree (DT) and Support Vector Machine (SVM) which have a greater capacity to handle huge and noisy data that are used to predict accidents with more accuracy. The methods used, prove to handle noisy, unrelated and missing data. The prediction results are tabulated and ranges between 85% to 90%.

Keywords: SVM; DT; Accident Prediction;

1. INTRODUCTION

This work focus on using data mining techniques in the process of accident prediction with aircraft accident details as training data set. Data from National Transportation Safety Board (NTSB), which records all the aircraft accidents, is used as training dataset for the proposed system. Various attributes which caused the accidents are analyzed. Collectively a set of ten attributes with one year of accident records are used as the training set. Huge Collection of past accident records of all types are

available in different formats and found to be erroneous. Fields and records which support the aircraft accident prediction are filtered.

On the normalized data, SVM is applied to predict the future possibility of accident occurrence. SVM implements mapping of inputs into a high dimensional space using a set of nonlinear basis functions. For cross validation or to measure the accuracy level of SVM, further techniques are implemented to predict accidents. DT which can handle nonlinear data in a more effective way is implemented and tested.

This paper is organized as follows. Section 2 gives a detailed literature review, section 3 defines the problem, section 4 describes the dataset selection, section 5 explains the preprocessing stages, section 6 discuss the methods, section 7 provides the accuracy, section 8 shows the implementation, section 9 draws the conclusion and finally section 10 presents future work.

2. LITERATURE REVIEW

Many researches have been done on the prediction of aircrafts accidents. We start the section by presenting some related works in prediction in general.

"Hybrid safety and analysis method based on SVM and RST", [1] *Ying Dai, Jin Tian, HaoRong, Tingdi Zhao*, research paper focused on providing a safe landing without an accident.

"Data mining approaches for aircraft accidents prediction", [2] by *A.B Arockia Christopher and Dr. S.Appavu*, used decision tree method to predict the warning level. Dataset used are pilot details, delay details, accident related details, maintenance details and flight details.

A.B Arockia Christopher and Dr. S.Appavu[3] analyzed various data preprocessing techniques to find best techniques which suits for airline data. Classification algorithms and many clustering techniques are used in for comparison. The data mining tool weka was used in this process. As a result of this analysis they have proved that Principal Components Attributes (PCA) Transformer would perform better than other attribute evaluators on airline data to reduce the dataset. On an empirical study on Turkey airline, decision tree technique is used to generate model. This model in turn is used to predict the warning level.

A similar research, "Analyzing Relationships between Aircraft Accidents and Incidents", [4] *ZohrehNazeri*, *George Donohue, Lance Sherry*, was done in USA. In this research various accidents and causes for these accidents are analyzed. Accident details from NTSB database and reasons for these accidents are maintained. Taxonomy was used for filtering the data. In order to maintain a uniform data structure data transformation is applied to transform the report into a vector containing common fields. Then STUCCO algorithm as used for finding the pattern.

The result from the finding is then ranked using factor support ratio measure. Accuracy level of the output produced is also determined using accuracy algorithm.

3. PROBLEM DEFINITION

Understanding and processing an unstructured and dynamic data is a tedious work. Airline data are dynamic and seems to be unpredictable. Accidents and incidents may happen due to human or others natural calamities. Natural happenings such as bad weather, storm and birds happen suddenly which should be handled dynamically. Human errors can be avoided by proper planning and maintenance. Thus to process uncertain data, the usage of proper tools and techniques are needed.

4. DATASET SELECTION

Data from the database NTSB is used. Thousands of records from five to eight years are collected and stored for analysis. Pilot, runway, air speed and timing related data are collected and stored in the database.

The following attributes values are used as training data set, event start date, event end date, month, city, state, country, type (accident or incident or both), injury severity, aircraft details like category, make, model, registration, damage, number of engines, operation information like purpose of flight, schedule, air carrier and event details like airport name, code, weather condition, location of the accident, latitude, longitude.

5. DATA PREPROCESSING

Huge amount of data recorded from various accidents are available. National Transportation Safety Board (NTSB) [7] maintains a detailed record of all types of accident data. Field values may be missing or not available or not suitable for prediction or it may lead to wrong prediction. To overcome these problems data has to be pre-processed before starting the analysis. The process of cleaning involves filling of missing values, removing of unrelated attributes.

$$x = \frac{1}{N} \sum_{i=1}^{N} x_i \qquad (1)$$

Data preprocessing is done on the available data. As the first step, data cleaning is done where the missing values are replaced by the attribute mean value.

Data filtering is done to extract recent records. Data sets for analysis contain hundreds of attributes, many of which are redundant and found to deviate the prediction process. Attribute subset selection reduces the data set size by pruning irrelevant and redundant attributes. At the end of data preprocessing stage a clean record is formed. The list of attributes considered in this work are weather condition, landing runway, pilot, injury severity, schedule, aircraft damage, aircraft category, engine type, location, and model as the key feature in accident prediction. Fig.1 depicts stage by stage data preprocessing steps.
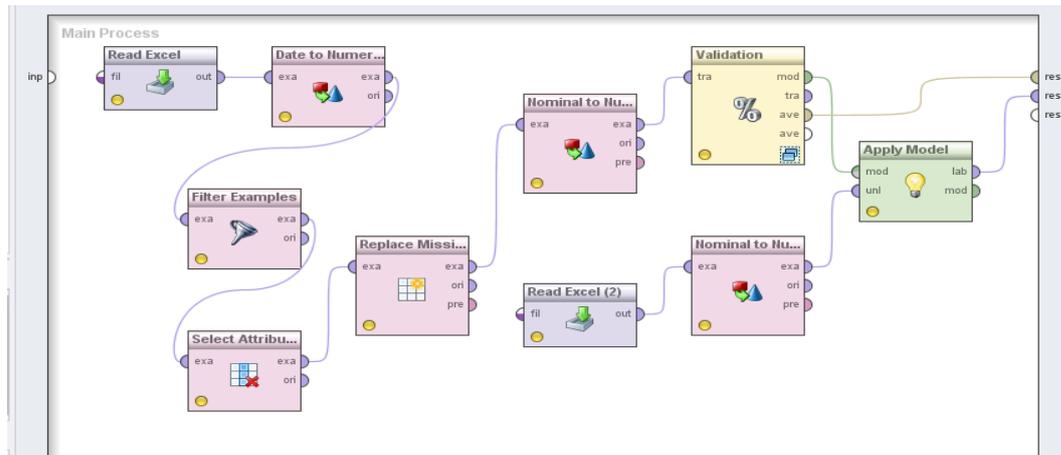

Fig 1. Data Preprocessing Stages.

(a) Type conversion: Normalization, (b) Attribute selection: Removing unrelated or unwanted attributes, (c) Replace missing values: Removing or replacing the missing values with its mean value and (d) Data filtering: here we focus on the recent records and so we remove old records are the processes which a data has to undergo before applying any technique. Fig.1 explains the flow pictorially.

6. METHODS

Data mining has techniques to process unstructured and dynamic data. In this paper, prediction algorithms such as DT (Decision Tree) and SVM (Support Vector Machine) are used to predict the warning level.

6.1 SUPPORT VECTOR MACHINE

SVM is a promising method for the classification of both linear and nonlinear data by a separating hyper-plane. It is a supervised learning technique from the field of machine learning applicable to both classification and regression. The appropriate set kernel function is chosen to handle high dimensional non-linear data set. The

polynomial kernel function is used for classification. A multi-dimensional hyper-plane is formed which classifies the data as cause of accident and does not cause accident. The kernel function is given below.
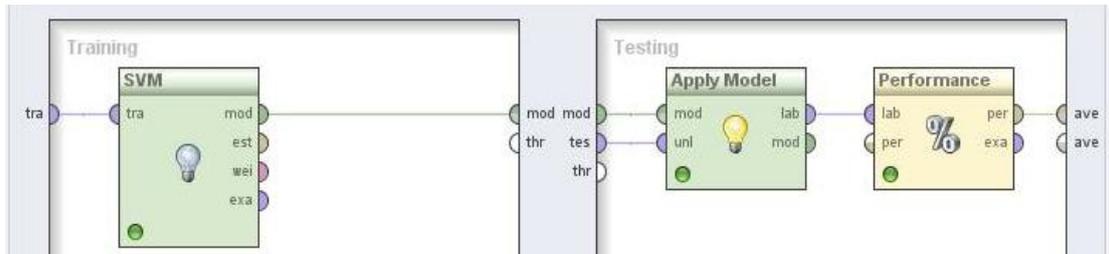
$$K(x, y) = (x^T y + c)^d \tag{2}$$

Fig.2. SVM and its performance measure operators.

Fig.2 shows how SVM is used to predict the result from the test data. Each training set is applied as test set for better accuracy.

Table 1. Accuracy percentage of SVM after Dimensionality Reduction.

Class Precision	true No	true Yes	
98.67%	1	74	Pred. Yes
96.97%	32	1	Pred. No
	96.97 %	98.67 %	Class Recall

The predicted result by SVM under goes for the performance validation. The accuracy of result obtained is determined by using confusion matrix.

6.1.2 DIMENSIONALITY REDUCTION

In dimensionality reduction, data encoding transformations are applied so as to obtain a reduced or compressed representation of the original data. Random Forest based approach, is applied for dimensionality reduction. It generates a large and carefully constructed set of trees against a target attribute and then uses each attribute's usage statistics to find the most informative subset of features. A statistical analysis is made on each tree and five major attributes which causes the accident are chosen for further prediction process. The attributes pruned are weather condition, landing runway, pilot, injury severity and schedule. With the selected attributes we are able to achieve greater accuracy (refer Table 1).

6.2 DECISION TREE

ID3 is the decision algorithm used for accident prediction. ID3 uses information gain as its attribute selection measure. It decides which attribute (Splitting point) to test at node N by determining the best way to separate or partition the tuples into individual classes.

Entropy is a measure of the uncertainty associated with a random variable. As uncertainty and or randomness increases for a result set so does the entropy.

$$H(X) = -\sum_{i=1}^{n} p(x_i) \log_b p(x_i) \qquad (3)$$

In Fig.3 decision tree shows the prediction of accident with major attributes that has been filtered.
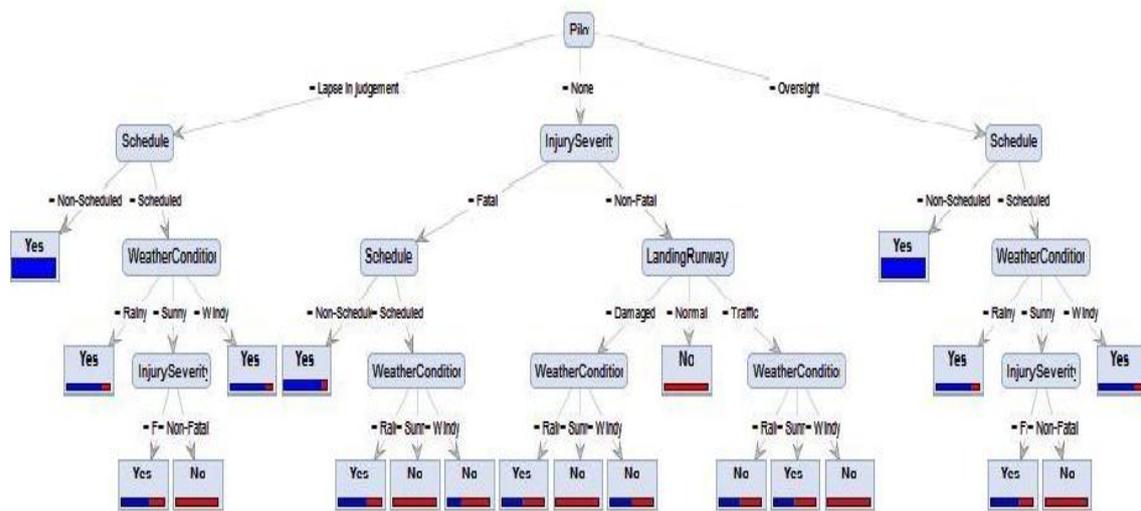

Fig. 3. Accident Prediction using Decision Tree.

Decision tree gives a visualization of accident prediction. Easy analysis can be made by any one (refer fig. 3).

7. ACCURACY MEASURE

Accuracy is measured for each algorithm. Confusion matrix is used for calculating accuracy. It is a useful tool for analyzing the classifier to recognize the efficiency of the tuples of different classes. The error rate or misclassification rate of a classifier M, which is simply (1 - Accuracy) . Accuracy can be calculated as follows,

$$\text{Accuracy} = \frac{TP+TN}{TP+FN+FP+TN} \qquad (4)$$

7.1 PERFORMANCE AND ACCURACY MEASURE

Method 1 – Support Vector Machine
Accuracy: 96.27%

TABLE 2. Accuracy Percentage of SVM

Class Precision	true No	true Yes	
96.10 %	3	74	Pred. Yes
96.77 %	30	1	Pred. No
	90.91 %	98.67 %	Class Recall

Method 2 – Decision tree
Accuracy 90.73%

TABLE 3. Accuracy Percentage of DT

Class Precision	true No	true Yes	
95.77 %	3	68	Pred. Yes
81.08%	30	7	Pred. No
	90.91 %	90.67 %	Class Recall

7.2 ACCURACY COMPARISON OF SVM and DT

TABLE 4. Accuracy Measures of SVM and Decision Tree

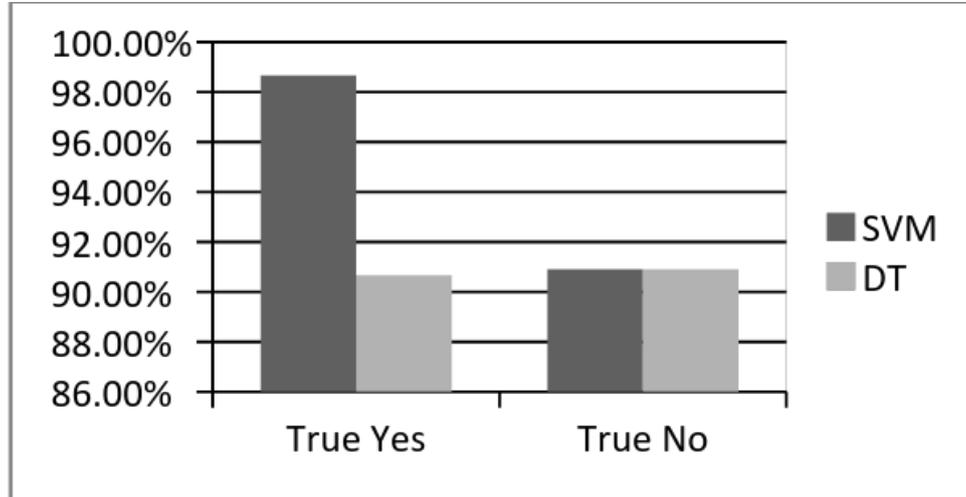| True No	True Yes	
90.91%	98.67%	**SVM**
90.91%	90.67%	**DT**

7.2.1 COMPARISON CHART

Fig.4. Accuracy Comparison chart of SVM and DT.

Fig.4 depicts the accuracy comparison of algorithms implemented. The prediction level of yes and no by each algorithm is clear and SVM produced highest accuracy in prediction.

8. IMPLEMENTATION

Aircraft Accident Prediction is achieved through a powerful tool in data mining, called Rapid Miner. Rapid Miner is a software platform that provides an integrated environment for machine learning, data mining, text mining, predictive analytics and business analytics.

Using Rapid Miner, decision tree and SVM have been implemented. Accuracy being a main part, it is estimated in each phase for better prediction.

9. CONCLUSION

Data mining efficiently acts here by predicting useful information from big, past and noisy data. Prediction of aircraft accident is a critical factor. Thus it has been implemented with two efficient data mining algorithms SVM and Decision Tree. These algorithms are efficiently used in medical sector to find cancer and kidney disease, crime prediction, weather prediction, banking sectors, marketing and in many other sectors. Two algorithms acts efficiently in different real time conditions. On usage of these algorithms aircraft accident has been predicted with more accuracy.

ADVANTAGES OF AIRCRAFT ACCIDENT PREDICTION:

Safety is always concerned in any field. Many researches using various techniques have been done to over avoid the accidents. Aircraft accident prediction analysis various factors and find the unknown data. It helps in the prediction of pilot behavior, climatic changes, climatic condition, suitable condition for aircraft flying, condition or situation which causes accident and many others. These behavior understanding helps in accident prediction and it also helps in finding the behavior of pilot and weather condition. Various factors which causes accidents are analyzed. This prediction prevent accident which intern saves many human lives and also the property.

10. FUTURE WORK

Data source from across the countries can be collected and analysed for better prediction. On successful implementation of aircraft accident prediction system, it can be further extended to railway and road ways. Implementation of these predictions system saves life and cost.

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